

CHAPTER 5

GEOSPATIAL DATA SYSTEMS (GDS)

5-1. Introduction.

a. The purpose of this chapter is to describe and discuss the geospatial data and geospatial data system (GDGDS) considerations including location surveying and mapping that should be addressed by the PDT for a munitions response project. The PDT should develop project-specific GDGDS, location surveying and mapping requirements for inclusion in the SOW for each munitions response project. Application of procedures required for surveying and mapping may vary depending on the type of contracting methodology being used to execute the work, however they should be used to the extent practicable. Table B-5 in Appendix B is a checklist of GDGDS and location surveying and mapping considerations.

b. USACE has various contract vehicles that may be used for obtaining location surveying and mapping services. Services may be supplied by the government as Government-Furnished Information (GFI) / Government-Furnished Equipment (GFE) or may be requested within the SOW of the munitions response. Some munitions response projects may not require any specialized capabilities, while others may require comprehensive capabilities.

5-2. Requirements for the Acquisition and Access of Geospatial Data.

a. This chapter presents guidance in developing GDS requirements associated with a munitions response, specific SOW requirements, and technical or management considerations. ER 1110-1-8156 - Engineering and Design - Policies, Guidance, and Requirements for Geospatial Data Systems establishes general criteria and presents guidance for the acquisition, processing, storage, distribution, and utilization of geospatial data.

b. EM 1110-1-2909 - Geospatial Data and Systems identifies standards for GDS acquired, produced, and/or utilized in support of a munitions response project. There are many techniques that may be used to acquire the geospatial data required in support of a munitions response. Requirements for obtaining this data should be result-oriented and not overly prescriptive or process oriented IAW EM 1110-1-2909. Project requirements will set forth the end results to be achieved and not the means, or technical procedures, used to achieve those results. They will succinctly define GDGDS requirements as derived from the functional project requirements developed by the PDT, and they will reference EM 1110-1-2909 and other applicable industry standards.

5-3. Data Quality Objectives. The PDT will review the archival records of the project area or installation in which the project is located and inventory all existing GDS information prior to

developing site-specific DQOs. Chapter 7 – Geospatial Data Issues and Standards, from EM1110-1-2909, shall be used as guidance when no other standards or legacy system exists.

a. Geospatial Data System. The PDT will review the extent of Geospatial Data System (GDS) currently utilized by the MM CX, MM DC, district, customer, and stakeholders. Any automated system that employs or references data using absolute, relative, or assumed coordinates is considered a GDS. These include GIS, Land Information Systems (LIS), Remote Sensing or Image Processing Systems, Computer Aided Design and Drafting (CADD) systems, and Automated Mapping/Facilities Management (AM/FM) systems. The selected GDS should accomplish today's mission, but also allow for future reuse or use of the geospatial data by others without translation. Production of geospatial data in multiple formats for distribution or use should be avoided wherever possible. This means that the data formats selected should be open rather than proprietary. For example, Tagged Image File Format (TIFF, or “.tif”) files should be used to store imagery rather than Photographic Experts Group (JPEG) (or “.jpg”) files or bitmap (BMP, or “.bmp”) files, as TIFF is considered an open standard. Compatible formats for spatial data should also be selected wherever possible (e.g. ArcView shapefiles, which can usually be shared between several software applications). Project requirements may dictate the use of a particular proprietary software package and/or database format. In these cases, the final data product should be exported to an open format at the close of the project to ensure long-term data survivability and compatibility. For example, tabular databases should be exported to an American Standard Code for Information Interchange (ASCII) format, with appropriate documentation. Spatial data should be exported at the close of the project to an open format such as Spatial Data Transfer Standard (SDTS) or Drawing Interchange File (DXF) format.

b. Spatial Coordinate Reference System. All munitions response projects should be adequately connected to nationwide or worldwide geographic reference systems. All geospatial data should be indexed to existing local, state or national control monuments and referenced to an appropriately recognized installation, local, state, or worldwide coordinate system as specified by the PDT. The PDT should select a spatial coordinate reference system that is compatible with existing district or customer GDS activities. Unless otherwise indicated, it is recommend that all spatial data be stored using the Universal Transverse Mercator (UTM) Coordinate System, using either North American Datum of 1983 (NAD83) or World Geodetic System of 1984 (WGS84) for horizontal control. Horizontal coordinates will be stored using metric units. Vertical control, if required, will also be based on metric units and referenced to North American Vertical Datum of 1988 (NAVD88). Project-specific requirements may dictate the use of an alternate coordinate system, datum, and measurement units, but deviations from this standard should only be made after careful deliberation and with full recognition of the potential impacts. For projects located outside the continental United States, local conditions may warrant the use of an alternate vertical datum.

c. **Geospatial Data Standards.** GDS users need geospatial data standards to manage this data, reduce redundant data, make systems more efficient, and lower project costs. The Tri-Service CADD/GIS Technology Center's Spatial Data Standards for Facilities, Infrastructure, and the Environment (SDSFIE) should be specified for all deliverables of collected geospatial data. The SDSFIE data standard is available from the CADD/GIS Technology Center, and online at <http://tsc.wes.army.mil>. The PDT should develop additional site-specific standards for the format, transfer, and storage of all geospatial data consistent with EM 1110-1-2909. Factors influencing formulation of project-specific standards include:

- (1) Compatibility with selected GDS without modification or additional software.
- (2) Format of existing digital data and geospatial-referenced mapping.
- (3) Usability by all parties of concern, including stakeholders.

d. **Measurement Units.** Geospatial data produced in support of a munitions response project should be recorded and plotted in the units prescribed for the project by the district or customer. The use of metric units is recommended unless superseded by project-specific requirements.

e. **Control Markers.** Project control markers may consist of markers and/or benchmarks established by any Federal, state, local, or private agency with positional data within the minimum acceptable accuracy standards prescribed by the PDT. The PDT may require an increase in existing project control markers. Ties to local USACE or installation project control and/or boundary markers are absolutely essential and critical except when unfeasible or cost prohibitive. In order to minimize scale and orientation errors, at least two existing markers should be used as a baseline for the project geospatial coordinate reference system.

f. **Accuracy.** Every observed or measured spatial data element contains errors of a certain magnitude due to a variety of causes. The PDT should evaluate data requirements and develop acceptable limits of error (accuracy and precision) based upon the nature and purpose of each location surveying and mapping activity or product. Engineering and construction surveys are normally specified and classified based on the minimum acceptable horizontal (linear) point closure ratio and vertical elevation difference standard. Standardization of equipment and instruments used in acquiring geospatial data and producing location survey and mapping products is required to improve the accuracy of the integrated conclusions.

g. **Reliability.** The development of an effective GDS facilitates a systemized approach to a munitions response project using all digital data and life cycle management of all applicable geospatial data. Provision should be made for larger-scale projects to facilitate the sharing and dissemination of data using web-based tools and applications where possible (i.e. web-based mapping services such as ArcIMS or Geosoft's Oasis Montaj for data review and analysis).

This will avoid data duplication and will serve to centralize and standardize database stewardship functions IAW the overall goal of improved life cycle data management. The project GDS should provide a full digital record of all on-site activities with a reproducible trail to support ongoing and future Administrative Record decisions. The GDS designated in the SOW by the PDT should provide reliable results, support greater overall productivity, and lower total project costs.

h. Data Preservation. The closeout of a project should include steps to archive the data using open data formats as described above, and using stable digital media to ensure long-term survivability. The specific media chosen will change as the technology changes, but care should be taken to select only the most stable and widely used formats. These media will be refreshed on a regular 5 to 10 year cycle, and it is of utmost importance that the media be readable and accessible when the scheduled refresh occurs.

5-4. QC. The primary goal of data quality management is to ensure a consistent and measurable accuracy throughout the database. Consistency is achieved through the use of documented, approved production procedures. Following production, an assessment of the quality of the data set should be conducted to measure the level of achievement of the expected results.

a. The PDT should establish the level of production control and rigor with which quality assessments should be made consistent with the project-specific GDS requirements. GDS with stringent accuracy and consistency requirements may need to have detailed procedural documentation, a completion signature for each production step, and a comprehensive assessment of accuracy. Conversely, smaller-scale GDS developed for production of background geospatial data may have much less stringent production documentation requirements and only a cursory accuracy assessment.

b. The PDT should state in the SOW that QC of the GDS activities and products should be performed by the contractor and include independent tests which may be periodically reviewed by the government. Therefore, USACE Quality Assurance (QA) and testing functions will focus on whether the contractor meets the required project requirements.

5-5. SOW.

a. General. The GDS standards and requirements for each munitions response project SOW should be prepared by PDT personnel with detailed knowledge of the project history, archival information, various GDS platforms, location survey and mapping methodologies, and project-specific data requirements. The SOW will require consideration of the following in development of the Work Plan:

- (1) Project and property boundaries.

- (2) MEC types, hazard levels, and contamination levels.
- (3) Potential Sources of MC including firing lines, targets, OB/OD areas, etc.
- (4) Project location, size, topography, and vegetative cover.
- (5) Extent of existing planimetric features.
- (6) Density and accuracy of existing control markers.
- (7) Mission and objectives of the munitions response.
- (8) Positioning requirements of proposed geophysical detection systems.
- (9) Data formatting, transfer, and storage.

b. Personnel Requirements. The PDT should ensure that the munitions response project SOW specifies that a qualified GIS manager should manage all GDS activities. The PDT will ensure that the SOW also discusses personnel requirements for a Registered or Professional Land Surveyor and a qualified UXO technician for locational surveys.

(1) GIS Manager. The SOW should specify that the individual will have a minimum of three years of direct experience managing geospatial data systems within the specified system environment (i.e., ArcGIS, GeoMedia, or Modular GIS Environment (MGE)).

(2) Registered or Professional Land Surveyor (RLS/PLS). The PDT will ensure that the Munitions Response SOW specifies that boundary work, legal descriptions or parcel closure information will be completed under the responsible charge of a RLS/PLS. The RLS/PLS should be registered and/or licensed by the appropriate Board of Registration, or an acceptable equivalent, for the state in which this work will be conducted. The RLS/PLS will only be required to sign drawings that contain boundaries, legal descriptions, or parcel closure information. Signatures are not required for site characterization grid coordinates and ordnance location data and these tasks can be overseen by an RLS/PLS registered in any state. In addition, the Field Surveyor assigned to the munitions response project will have a minimum of five years experience as a Survey Party Chief.

(3) UXO Technician II. The PDT should also assure that the SOW requires a qualified UXO Technician II to accompany the Field Surveyor during all field surveying and mapping activities. The UXO Technician II will conduct visual surveys for surface MEC prior to the Field Surveyor entering a suspected MEC-impacted area. A survey with a geophysical instrument will be performed at each intrusive activity location to ensure that the location is anomaly-free prior to the installation of monuments, driving stakes, or performing any other intrusive activity. Based on site conditions, it is possible that a UXO Technician II will not be

required in all areas at all times after the initial site visit. However, such a decision will be made jointly by the UXO Technician II and the USACE OE Safety Specialist who may rescind or modify this decision at any time.

c. Safety. It is the responsibility of the PDT to assure that the contractor is informed in the SOW to follow the safety requirements in EM 385-1-1.

d. Resources. For general guidance on the development of surveying and mapping requirements, the PDT may reference EM 1110-1-2909. GPS surveying services may be required as an integral part of the location surveying and mapping effort. EM 1110-1-1003 provides technical requirements and procedural guidance for surveying with GPS and includes a guide specification for development of SOWs with GPS survey requirements.

5-6. GDS Plan.

a. General. Prior to initiating project activities, a Geospatial Data & Systems Plan will be prepared. This plan, which is a chapter in the Work Plan, is prepared to describe the project requirements, proposed technical methodologies and procedures, and equipment recommendations for all GDGDS activities that will take place during a munitions response project.

b. Contents. When reviewing the Geospatial Data & Systems Plan, the PDT will ensure that the following elements are addressed:

(1) Locating existing Geospatial Data (types and accuracy).

(2) Collection of additional geospatial data including data from locational surveys (types, accuracy and location).

(3) Proposed system methods and procedures (hardware and software, personnel, work instructions/data formats and standards, data processing, analysis support, communication/data transfer, data sharing, and data storage and archival).

(4) QC (data validation).

(5) Deliverables.

c. Review and Approval. The Geospatial Data & Systems Plan will be submitted as a chapter of the Work Plan to the PM and the MM DC. The MM DC will route the plan to the appropriate USACE technical staff for review and comment. Once approved by the PDT and CO, the Location Geospatial Data & Systems Plan represents the standard to which all geospatial activities are compared to assure compliance during the project. In the case of contractor execution, the approved Geospatial Data & Systems Plan is contractually binding.

5-7. Planning Considerations. Each munitions response project requires selection of an appropriate GDGDS that will accomplish the end objective without wasting manpower, time, and money. The PDT will ensure that the following items are considered when planning for the location surveying and mapping task.

a. Spatial Data Reference System. Unless otherwise indicated, it is recommend that all spatial data be stored using the UTM Coordinate System, using either NAD83 or WGS84 for horizontal control. Horizontal coordinates will be stored using metric units. Vertical control, if required, will also be based on metric units and referenced to NAVD88. Project-specific requirements may dictate the use of an alternate coordinate system, datum, and measurement units, but deviations from this standard should only be made after careful deliberation and with full recognition of the potential impacts. For projects located outside the continental United States, local conditions may warrant the use of an alternate vertical datum.

b. Project Control Markers.

(1) The requirements for new or additional project control markers should be based on the availability of existing control markers, the type of location surveying equipment proposed, and the level of accuracy required for the type of activities proposed under the specific munitions response project. Permanent concrete monuments are typically used for project control. Requirements for permanent markers are set forth in EM 1110-1-1002 and should be reviewed in consideration of the following:

- (a) Located within the project limits with a minimum separation of 100 meters.
- (b) Set 10 meters from the edge of any existing road inside the project limits.
- (c) Constructed with the top set flush with the ground and the bottom at a minimum of 0.6 meters below frost depth.

(2) Accuracy.

(a) The minimum accuracy standards for horizontal and vertical control will be Class I, Third Order or better. Unless otherwise specified, all spatial data will be stored using the UTM Coordinate System, using either NAD83 or WGS84 for horizontal control. Horizontal coordinates will be stored using metric units. Vertical control, if required, will also be based on metric units and referenced to NAVD88. Project-specific requirements may dictate the use of an alternate coordinate system, datum, and measurement units, but deviations from this standard should only be made after careful deliberation and with full recognition of the potential impacts. For projects located outside the continental United States, local conditions may warrant the use of an alternate vertical datum, and WGS84 is the preferred horizontal datum.

(b) If aerial photographs or orthophotography are used to provide the survey, the aerial targets used for control points will meet the same horizontal and vertical accuracy requirements detailed above.

(3) Monument Caps.

(a) The caps for any new monuments established will be 3-1/4 to 3-1/2 inch domed brass, bronze or aluminum alloy and stamped in a consecutively numbered sequence. The proposed identification stamping for each monument will be provided in the Location Surveys and Mapping Plan consistent with the following:

(Project Name) - (Numerical Sequence) - (Year) (Contracting MM DC)

(b) The dies for stamping the numbers and letters into these caps will be 1/8 inch to 3/16 inch in size. All coordinates and elevations will be shown to the closest one-thousandth of a meter (0.001m) and one-hundredth of a foot (0.01 feet).

(4) Monument Descriptions. Monument descriptions will be required for all control monuments established or used for the munitions response. These descriptions will be captured within the GIS database, in a standard relational database, or in a spreadsheet. Accompanying maps will show the location of the monument relative to other spatial features so that the monument can be easily recovered. The monument descriptions and map(s) will include the following:

(a) Map showing location relative to reference marks, buildings, roads, railroads, towers, trees, etc. Map will include north arrow and scale.

(b) A text description in the database or spreadsheet telling how to locate the monument from a well known and easily identifiable point.

(c) The monument's name or number (stored in the database or spreadsheet).

(d) The final adjusted coordinates and elevations in meters and feet (to the closest 0.001m and 0.01 feet) stored in the database or spreadsheet.

c. Project Boundaries. Project boundaries will be delineated with permanent or semi-permanent markers, such as iron pipe or pins consistent with state or local subdivision requirements. The accuracy standards for the location of project boundaries will be equal or greater than minimum standards for property boundary surveys established by the state within which the project is located.

d. Local Control Points. Local control points (i.e., grid corners, aerial targets) will be established using plastic or wooden hubs unless otherwise specified by the PDT. The accuracy

standards for aerial targets established as control points for aerial photographs or orthophotography will be the same as those prescribed for project control monuments. Accuracy standards for grid corners should be consistent with the mission and objectives of the munitions response effort.

e. Anomalies, Recovered MEC, and Environmental Samples. All recovered MEC, environmental samples, and any subsurface geophysical anomalies not completely investigated should be located. Each location will be estimated or measured for an approximate accuracy of plus or minus one foot.

5-8. Mapping. The PDT should review the extent of mapping requirements to be included in each munitions response project SOW. The PDT should assure that the SOW states that all maps and drawings to be provided under the task are sealed and signed by the RLS/PLS. The Tri-Service CADD/GIS Technology Center's SDSFIE should be specified for all location survey and mapping deliverables of CADD, GIS, and other spatial and geospatial data IAW EM 1110-1-2909. The PDT will ensure that the following maps are provided:

a. Location Maps. A location map showing the project location and surrounding points of interest will be required. The map(s) should be produced at a scale no smaller than 1:2400 or 1":200' (or 1:2500 for metric scale).

b. Hard Copy Project Maps.

(1) A map of all project-related points of interest should be produced and delivered at a scale specified by contract requirements. The Project Map should show the location and identification of all of the project control monuments recovered and/or established at the project property in support of the munitions response, local project controls, significant planimetric features, project boundaries, and property boundaries (if in close proximity to project boundaries). The location of recovered MEC should also be plotted and identified on the map unless individual grid maps are also required.

(2) General Project Map requirements should also include grid, magnetic, and true north arrows with their angular differences; grid lines or tic marks at systematic intervals with values shown on the edges of the map; and a legend showing the standard symbols used for the mapping. Each sheet will also have a standard border, a revision block, and a complete index sheet layout.

(3) Grid Maps. If required, individual maps for each grid should be prepared at a scale no smaller than 1:2,400 or 1":200' (or 1:2500 for metric scale). The Grid Maps will include the plotted location of each surface MEC and verified subsurface MEC recovered, and each subsurface geophysical anomaly within the grid not completely investigated and any environmental samples. Other notable planimetric features within the grid will also be sketched on the individual Grid Maps.

(4) All production and work files, as well as all supporting data, will be fully documented into a concise data manual. This manual will include all specific information required for an outsider to be able to recreate all products and determine the location, names, structures and association of the data. The manual will be included as an ASCII file titled READ.ME that is included with all distributed digital data.

5-9. Deliverables. All deliverables will be submitted IAW contract requirements. When applicable, deliverables will be submitted in electronic format. The following deliverables will be submitted to the PDT following the location survey and mapping task (the submittal dates should be specified for each delivery order):

- a. Original copies of all field books, layout sheets, computation sheets, abstracts and computer printouts.
- b. Tabulated listing of all project control markers established and/or used in support of the munitions response showing adjusted horizontal and vertical positional values in meters and feet.
- c. Tabulated listing of all MEC recovered and any specific anomalies not completely investigated.
- d. Tabulation of MC sample locations included in project.
- e. Completed monument descriptions, stored in the GIS database, spreadsheet, etc.
- f. Unique items created and/or used to create the end products and the narrative and description required by the SOW.
- g. Required location, project, and grid maps.
- h. The negatives and three sets of prints of the aerial photographs taken for the project, if aerial photography is required in the SOW.
- i. All maps will be prepared using industry standard sheet sizes and formats. Project-specific reporting requirements may dictate the use of a variety of sheet sizes to show relevant information. The PDT will determine the number of maps and copies of digital data to be delivered to the MM DC.
- j. No digital data will be acceptable until proven compatible with the GDS designated in the SOW. All revisions required to achieve compatibility with the SOW-designated GDS will be done at the contractor's expense.

k. Deliverables will be submitted to the PDT IAW contract requirements. Whenever appropriate, deliverables should be submitted electronically. Deliverables which should be submitted upon completion of the munitions response project include:

(1) Unique items created and/or used to create the end products and the narrative and description required by the SOW.

(2) Digital data in the media as specified in the SOW (non-proprietary data file formats on stable digital media) along with all other supporting files and a data manual documenting all production and work files.

1. In all development of GDS data, consideration shall be made to address the Life Cycle Data Management aspects of the development, modification, storage, and re-use of geospatial data. Meta-data shall be complete and thorough to allow publication of individual dataset through any one of the following sources:

(1) National Geospatial Data Clearinghouse (Clearinghouse) - a distributed, electronic network of geospatial data producers, managers, and users operating on the Internet. The Clearinghouse is a key element of EO 12906 and will allow its users to determine what geospatial data exist, find the data they need, evaluate the usefulness of the data for their applications, and obtain or order the data as economically as possible.

(2) USACE Clearinghouse Node – HQUSACE established and maintains a computer network server on the National Geospatial Data Clearinghouse. This node functions as the primary point of public entry to the USACE geospatial data discovery path in the Clearinghouse. A separate electronic data page for each USACE Command has been established on the server. The Internet Universal Resource Locator (URL) address for the USACE Clearinghouse node is http://corps_geol.usace.army.mil.

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